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MATERIALS RESEARCH LABORATORIES

MELBOURNE, VICTORIA

REPORT

MRL-R-760

SIZE AND LUMINANCE DISCRIMINATION

IN THE PERIPHERAL VISUAL FIELD

Stephen E. Jenkins

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ABSTRACT

The detection of a stimulus in a complex environment is likely to depend on how different the stimulus is from the other elements in the visual field. The discrimination of length differences of two bars and size and luminance difference of two discs were measured as functions of the angle of eccentricity between the fixation point and the stimulus. The experiments were undertaken to provide basic data necessary for the interpretation of later experiments involving the detection of discs embedded in a complex background which in turn elucidates the determinants of camouflage. It was found that (1) discs are discriminated in size by virtue of their difference in diameter rather than their difference in area, (2) the 50% and 90% levels of detection probability of size and luminance contrast between two discs are linear functions of eccentricity at least to $14°$ eccentricity, (3) the visual system is better at discriminating size contrast at all eccentricities tested than it is at discriminating luminance contrast, (4) there is a fundamental difference between the mechanisms which mediate size and luminance discrimination. Models are proposed which could account for this difference.

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between the mechanisms which mediate size and luminance discrimination.
Models are proposed which could account for this difference.

C O N T E N T S

SIZE AND LUMINANCE DISCRIMINATION

IN THE PERIPHERAL VISUAL FIELD

1. INTRODUCTION

The detection of a camouflaged object necessitates a visual searching of the scene. The role of peripheral vision is vital in this process, for although the final detection of the target is by the fovea, it is peripheral vision which cues us for possible targets deserving closer interrogation by foveal vision.

For a visual stimulus to be seen when it is the only element in an otherwise uniform field, the stimulus must simply have a luminance that exceeds the threshold for the particular observation conditions. The threshold value of luminance depends on the background luminance, the angle between the line of the observer's fixation and the direction of the stimulus, and the size and duration of the stimulus. The detection of simple stimuli seen on uniform backgrounds has been studied exhaustively (Blackwell [1], Vos et al. [2], CIE [3]) and it is therefore possible to specify with some confidence the dimensions of a stimulus necessary for it to be seen.

When the stimulus is in a complex visual environment made up of many diverse elements, the processes of detection are less well understood and the specification of the stimulus dimensions necessary for it to remain undetected is correspondingly less certain.

It is unlikely that the detection of a stimulus in a complex visual environment can be successfully treated as an extension of the simpler case of detection on a uniform background. *It is more likely that detection depends on how different the stimulus is from the other elements in the visual field.* A stimulus can differ from its neighbours in luminance, size, colour and temporal characteristics, each of these dimensions is commonly used in practical situations to mark out a particular stimulus so that it will be noticed in a complex field.

Yet there is a paucity of empirical data describing discrimination of two neighbouring but separated objects. If the two objects differ in luminance or colour, some informed guess about visual performance may be made from classical discrimination data. However the typical stimulus for such data has been a bipartite field: when the two stimulus objects to be discriminated are separate, the absence of a common boundary introduces uncertainty about the applicability of classical data.

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Relatively little is known about size discrimination. Ono [4] showed that discrimination of the lengths of two parallel lines followed a Weber-type relationship when the lines were widely separated, so that the observers made a successive comparison looking first at one line and then the other. When the lines were less widely separated, the just-noticeable difference was independent of the length of the standard line, and discrimination appears to be akin to that of visual acuity. Similarly, Matthews [5] found that discrimination of the size of two separated discs was independent of the size of the disc. He found that threshold size difference was constant at about 30" for central fixation and increased linearly with the angle of eccentricity. This suggested to Matthews that size and visual acuity discriminations might be mediated by the same visual process. Thus the discrimination of disc size is a difference-of-length judgement (disc diameter) rather than a difference-of-area judgement.

Two experiments have been undertaken to establish threshold size and luminance difference for pairs of discs located at various angles of eccentricity from the fixation point and they provide basic data on the discrimination of two separate objects. These data can be used for the interpretation of later experiments involving the detection of a stimulus embedded in a complex background.

Because the result of Matthews [5] suggests that discrimination of size difference for pairs of discs may be based on discrimination of differences in diameter rather than in area, a third experiment involving discrimination of the length of two bars was also included. A comparison of size discrimination of two discs with length discrimination of two bars enables an inference to be drawn concerning the basis of the discrimination between discs of different sizes.

2. METHOD

The pairs of stimuli to be discriminated were prepared as 35 mm black and white transparencies and were projected on a screen subtending 40° horizontally by 27° vertically at the observers' eyes. At the geometric centre of each slide was a fixation cross on which the observers were required to maintain fixation. The pairs of stimuli were located at eccentricities of 3°, 6°, 10°, 14° and 18° on either side of the fixation cross. The stimulus slides were presented for 250 ms, and between successive presentations a blank field was projected. The blank field had a fixation cross in exact register with the stimulus-slide fixation cross. The luminance of the blank field was approximately the same as that of the background of the stimulus field.

All observers had visual acuity of $^6/6$ or better (wearing refractive correction if necessary) and were aged between 21 and 30 years. They observed binocularly in a darkened room and were required to respond either that the two stimuli in each presentation were 'different' (in size or brightness depending on the experiment) or that they were the 'same'.

2.1 Size discrimination of discs

In this experiment the stimulus was two discs of equal luminance arranged vertically above and below a horizontal line passing through the fixation point (Fig. 1(a)). One disc was the standard comparison disc which had a diameter of 72' and the other disc was either the same diameter or larger. The edge-to-edge separation of the two discs was held constant at 39'. The luminance of the discs was 23 cd/m^2 on a background of 9 cd/m^2.

An experimental run comprised 100 presentations made up of 10 presentations of the stimuli at each of the 5 eccentricities. The set of 10 presentations at each eccentricity comprised 3 in which the discs were of equal size and 7 in which the test disc was larger. Table 1 gives details of the size differences. Of the 11 size-difference conditions listed in Table 1, 7 were selected depending on the eccentricity: at 3° eccentricity the smallest 7 size difference conditions were used, at the 14° and 18° eccentricities the largest 7 size differences were chosen, with appropriate intermediate choices of size differences for the other eccentricities.

The presentations were divided into two sets. In the first set the presentations were grouped in order of eccentricity i.e. at each eccentricity the set of 10 presentations, randomly ordered, was shown and the observer was told which eccentricity was to be expected. In the second set all the fifty slides were randomly ordered and the observer had no knowledge of eccentricity or whether the stimulus would be to the right or left of the fixation cross. By running these two parallel experiments it is possible to judge whether an observer's ability to direct his attention is an aid to discrimination. There were 4 observers, each of whom made 10 experimental runs.

2.2 Luminance discrimination of discs

In this experiment the two discs were arranged in the same way as for the previous experiment (Fig. 1(a)) but were of the same size (diameter 72'). The luminance of the comparison disc was held constant at 23 cd/m^2 and the luminance of the test disc was either equal to this or greater. The luminances of the test discs are given in Table 1.

The experimental procedure was the same as for the preceding experiments. The same 4 observers made 10 experimental runs each, each run comprising 50 presentations. An experimental run consisted of 10 presentations of the stimuli at each of the 5 locations. For 3 of the presentations at each location the luminances of the two discs were equal and for the remaining 7 presentations the luminances differed by the amounts shown in Table 1. The 10 experimental runs included a random and ordered set.

2.3 Discrimination of bar length

In this experiment the stimuli were a pair of bars 12' wide arranged one above the other in either a vertical or horizontal orientation (Figs. 1(b) and (c)). The luminance of the bar was 5.5 cd/m^2 on a background of 0.9 cd/m^2. The standard bar was 72' long and the test bar was equally long or longer. The lengths of test bars are shown in Table 1.

For each orientation there were 5 experimental runs for each of 9 observers. An experimental run comprised 10 presentations at each of the 5 eccentricities, of which 3 presentations were of the equal-length bars. The presentations were grouped by bar orientation and within these two groups the stimuli appeared in random order to the left and right of the fixation cross.

3. RESULTS

3.1 Size and luminance discrimination for discs

The responses of the 4 observers were pooled for the ordered set and separately for the random set. Best-fit ogives were fitted by probit analysis for each eccentricity and for both size and luminance discrimination in both the ordered and the random sets. The 50% and 90% probability levels of the "different" responses were calculated and plotted against eccentricity in Fig. 2 for size discrimination, C_S, and in Fig. 3 for luminance discrimination, C_L.

The luminance discrimination of the two discs shows no adverse effect from the random presentation of eccentricities, and indeed the size discrimination shows a small improvement by observers in the random set. The data from both the ordered and the random presentations were consequently pooled and the results replotted in Figs. 4 and 5 together with the recalculated best-fit ogives. These ogives are collected and presented together in Fig. 6 for ease of comparison. It will be noted that there appears to be a characteristic difference between the response ogives for size discrimination and luminance discrimination. The ogives for size discrimination maintain an approximately constant variance (slope), whereas the response ogives for luminance discrimination show variances which increase with eccentricity. This difference in the characteristic shapes of the response ogives will be referred to later.

The responses to the zero-difference conditions did not contribute to the probit analysis of the data. They have however been used to calculate 'false-alarm' rates which were 60 out of 1200 (5%) for the size-discrimination task and 264 out of 1200 (22%) for the luminance-discrimination task. Points corresponding to these false-alarm rates are plotted in Fig. 6 on the ordinate axis and are consistent with the fitted ogives.

The values of size difference (C_S) and luminance difference (C_L) which give 50% and 90% probability levels of the 'different' responses were calculated and are plotted as a function of eccentricity in Figs. 7 and 8. The values of C_S and C_L increase with eccentricity in a linear fashion out to $14°$; the decrease at $18°$ may be real but is more likely to be an artifact of the experimental set-up. At $18°$ eccentricity, the discs are just $1\frac{1}{2}°$ to $2°$ from the dark edge of the surround. This may facilitate discrimination by 'localising' the task. Because of the uncertainty about the validity of the data at $18°$ eccentricity they are neglected in the fitting of the linear regressions in Figs. 7 and 8 and in subsequent analysis. The rejection of the $18°$ data is supported by the abnormal behaviour of the data as illustrated in Fig. 6.

The visual system appears to be better at discriminating size differences than luminance differences, particularly for the 90% probability criterion. For example at 10° eccentricity the test disc needs to be 25% larger in diameter (C_S = 0.25) for a difference to be detected with a 0.5 probability of being correct but there needs to be a 39% luminance difference. At the 0.9 probability level the size difference needed is 40% and the luminance difference is nearly 100%.

The p = 0.50 regression line for size discrimination is C_S = 0.21ε + 0.04. This describes a much poorer observer performance than that found by Matthews [5]. His func 'on for size discrimination discs against eccentricity is ΔD = 0.88ε + 0.6, where ΔD is the difference in diameter between discs expressed in minute of arc; our function expressed in terms of ΔD is ΔD = 1.51ε + 2.88. However, his experiment differs in some important ways from this experiment. His spatial arrangement of stimuli was horizontal so that the actual eccentricity of the two discs varied some 140' around the nominal value of eccentricity. Moreover Matthews elected to keep the centre-to-centre separation of his discs constant at 90' so that as test-disc diameter increased the edge-to-edge separation decreased, perhaps providing the observers with an additional cue.

3.2 Discrimination of bar lengths

The responses of the 9 observers have been pooled and a normal ogive fitted for each eccentricity by probit analysis. The data for the horizontal configuration are shown in Fig. 9 and for the vertical configuration in Fig. 10.

The 'false-alarm' rates are given in Table 2. The false-alarm rates do not change greatly with eccentricity for the vertical configuration and are generally larger than those found for the horizontal configuration. The false-alarm rates do increase systematically with eccentricity for the horizontal configuration. The picture that emerges from both the slopes of the ogives and the false-alarm rates is that the observers are more uncertain for the vertical configuration than they are for the horizontal, and that this uncertainty remains essentially unchanged with eccentricity for the vertical but uncertainty increases with eccentricity in the case of the horizontal format. The observers commented that they found the vertical configuration more difficult than the horizontal.

In Fig. 11 are plotted the length differences necessary for 50% and 90% probability of a correct response. At the 50% probability level there is no difference in threshold length discrimination for the two configurations out to an eccentricity of 14°, despite the fact that observers found the vertical configuration subjectively more difficult than the horizontal. There is a difference in the threshold C_S for the 18° eccentricity (p < .001) as a result of which the data for the horizontal configuration cannot be fitted with a linear regression. The data are much better fitted by a quadratic expression. It is possible that the data point at 18° eccentricity is spurious because of the proximity of the stimuli to the boundary of the field.

Although discrimination for the vertical and horizontal configurations are very similar out to 14° eccentricity this cannot be taken as a general

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statement, since the thresholds depend on the separations of the bars. It happens that for the separations chosen in this experiment comparable thresholds are found for the two configurations.

3.3 Comparison of bar and disc size discrimination

Discrimination of the size of discs is probably by discrimination of differences in diameter or differences in area. Comparison of the bar and disc discrimination functions shows that in this experiment discrimination is on the basis of differences in diameter.

At a given èccentricity (ϵ) there will be a test-disc size which can be discriminated from the standard disc 50% of the time. This disc may be characterised by a contrast in diameter

$$C_{SD} = (D_T - D_B)/D_B$$

or by a contrast in area

$$C_{SA} = (D_T^2 - D_B^2)/D_B^2 .$$

It has been shown (Fig. 5) that C_{SD} is a linear function of eccentricity and therefore C_{SA} is a quadratic function of eccentricity as $C_{SA} = C_{SD}^2 + 2C_{SD}$.

For the bar-discrimination task the expressions for C_{SD} and C_{SA} become identical since the bar widths do not change and only length is altered and the same function results whether the observer performs the discrimination by area or by length. In Fig. 12 it can be seen that, for the p = 0.5 criterion, the slope of the vertical-bar-discrimination regression line is similar to that of the disc-diameter function, (A t test on the regression coefficients shows that the slopes of the two functions are not significantly different, p > 0.05). Both functions are very different from the disc-area function. Similarly the horizontal-bar-discrimination function (fitted by a quadratic if the 18° data point is included) is quite different from the disc-area function and similar in magnitude to the other two functions. It is concluded that out to at least 14° from central fixation discrimination between disc sizes is carried out on the basis of differences in diameter not area.

3.4 Comparison of response ogives

It has already been noted that there is a difference in character between the ogives for size and luminance discrimination of discs. The size discrimination set of ogives maintains a reasonably constant variance σ^2, whereas the mean contrast C_M increases with eccentricity. For the luminance-discrimination set there is a steady increase in variance with eccentricity as well as an increase in mean contrast C_M. This is more clearly demonstrated if values of C_M/σ are plotted against eccentricity for both tasks.

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This is shown in Fig. 13. The different behaviour of the C_M/σ ratios suggests that the size and luminance discrimination are mediated, as might be expected, by different mechanisms.

4. DISCUSSION

On the basis of the data of the two-disc experiment it is possible to entertain some speculative models for the processes underlying discrimination of size and luminance differences for discs.

4.1 Luminance discrimination

The disc stimuli of the experiment are suprathreshold having photopic luminances and luminance contrasts of 1.6 with the background field. The observer's task was to detect the just-noticeable-difference in luminance between the two discs. Results from threshold detection experiments and the models they generate are unlikely to be valid at the suprathreshold levels of the present experiment.

The observer response ogives for the luminance discrimination show an increasing variance with eccentricity. It is believed that this is the result of increasing noise as the task is performed further into the peripheral field. It is proposed that the source of noise is due to the rod input to ganglion receptive fields, the noise increases as the proportion of rods to cones in ganglion receptive fields increases at larger eccentricities.

The receptive fields of ganglion cells receive inputs from both rods and cones (Dowling and Boycott, [6]); with increasing eccentricity there will be a decrease in the proportion of cones and an increase in the proportion of rods (Oesterberg, [7]; Kelly, [8]). The suprathreshold levels of the disc stimuli saturate the rods, rendering them ineffective in terms of useful response and they are simply a source of noise added to the cone signals.

It is argued then that with increasing eccentricity the physiological channels become increasingly noisy, this noise is generated in the retina and the luminance discrimination is determined by the magnitude of the signals from the ganglion receptive fields. As a consequence with increasing eccentricity there must be a larger signal difference in the neurological channels of the visual system in order to indicate a luminance difference with a given level of confidence, the response ogives show increasing variance and the observers greater uncertainty.

4.2 Size discrimination

For size discrimination the measured ogives maintain a constant variance but shift along the size contrast axis with increasing eccentricity. This suggests that the visual mechanism mediating this task maintains its sensitivity at all eccentricities, but there is a certain "dead-space" which increases with increasing eccentricity, i.e. the difference in diameter between the two discs must be above a critical difference before the mechanism will respond, and this critical difference is an increasing function of eccentricity.

It is known that at any given eccentricity there is a range of ganglion receptive field sizes (Graham et al., [9]; Fischer, [10]; Robson, [11]) and that the mean size increases linearly with eccentricity (Van Doorn et al., [12]; Koenderink et al., [13]). It is reasonable to assume also that as eccentricity increases the spacing between successive sizes of the respective field population, at a given retinal location, becomes progressively larger.

The luminance contrast of the two discs against the background field is sufficiently high to activate all sizes of ganglion receptive fields at one retinal location. In particular the smallest receptive field is activated by the disc image consequently the observer is aware of a sharp-edged disc at all eccentricities. It is the contention of this model that the size of the disc is coded by the cortex using the *positions* of the smallest receptive fields activated around the disc perimeter. This coding mechanism needs only positional information from the activated receptive fields and needs no knowledge about the magnitude of the retinal signal. The coding mechanism can then make the comparison between the sizes of the two discs *isolated* from the noise inherent in the retinal signals.

As the eccentricity increases the smallest receptive field size becomes larger consequently the *sampling* of the differences between the disc sizes is coarser resulting in an increasing amount of "dead-space" between response ogives at increased eccentricities.

The crucial difference between the models for size and luminance discrimination is that the luminance difference detector is served by the *magnitude* of the signals from the retinal receptive fields, and the size discrimination is served by the *position* coding of the disc perimeters carried out in the cortex and so is shielded from the variation in retinal noise with eccentricity.

Corroborative evidence that the two types of discrimination are mediated by different visual mechanisms can be found in some metacontrast studies by Spencer [14] and Schiller and Smith [15] where the masking stimulus was either a pattern mask or a luminance mask. Schiller and Smith showed that presenting a test figure to one eye and a luminance mask to the other brought no reduction in recognition performance, but presentation of a pattern mask to the other eye did impair performance on the test figure. This implies that luminance masking occurs at the retinal level and pattern masking at some higher level where the two retinal images are combined. Spencer investigated the identification of a single letter in relation to the interval between a luminance mask or a pattern mask and showed that the time courses for the two types of mask were quite different.

5. CONCLUSIONS

The discrimination of size and luminance differences of two discs has been measured as a function of the eccentricity from the point of fixation. It was found that discs are discriminated in size by virtue of their difference in diameter rather than their difference in area. The contrast in size and luminance between two discs needed to distinguish them with 50% and 90% levels of detection probability were found to be linear functions of

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eccentricity at least out to 14° from the point of fixation. The visual system is better at discriminating size contrast at all eccentricities than it is at discriminating luminance. The different characteristic shapes of the observer-response curves for size and luminance discrimination suggest that there is a fundamental difference between the mechanisms which mediate size and luminance discrimination. Models are proposed which could account for this difference.

6. ACKNOWLEDGEMENTS

7. REFERENCES

1. Blackwell, H.R. (1946). Contrast thresholds of the human eye. *J. Opt. Soc. Am.*, 36, 623-624.

2. Vos, J.J., Lazet, A. and Bouman, M.A. (1956). Visual contrast thresholds in practical problems. *J. Opt. Soc. Am.*, 46, 1065-1068.

3. C.I.E. (1971). Recommended method for evaluating visual performance aspects of lighting. *C.I.E. Report No. 19*.

4. Ono, H. (1967). Difference threshold for stimulus length under simultaneous and non-simultaneous viewing conditions. *Perc. & Psychophysics*, 2, 201-207.

5. Matthews, M.L. (1969). Visual size discrimination: effect of disc size and retinal locus. *Perc. & Psychophysics*, 6, 160-162.

6. Dowling, J.E. and Boycott, B.B. (1966). Organisation of the primate retina: electron microscopy. *Proc. Roy. Soc. B*, 166, 80-111.

7. Oesterberg, G. (1935). Topography of the layer of rods and cones. *Acta Ophthalmol.*, 13, 6.

8. Kelly, D.H. (1974). Effects of cone-cell distribution on pattern detection experiments. *J. Opt. Soc. Am.*, 64, 1523-1525.

9. Graham, N., Robson, J.G. and Nachmias, J. (1978). Grating summation in fovea and periphery. *Vis. Res.*, 18, 818-825.

10. Fischer, B. (1973). Overlap of receptive field centres and representation of the visual field in the cat's optic tract. *Vis. Res.*, 13, 2113-2120.

11. Robson, J.G. (1975). Receptive fields: neural representation of the spatial and intensive attributes of the visual image (eds. E.C. Carterette and P.P. Friedman), in *Handbook of Perception*, 5, 81-116. Academic Press.

12. van Doorn, A.J., Koenderink, J.J. and Bouman, M.A. (1972). The influence of the retinal inhomogeneity on the perception of spatial patterns. *Kybernetik*, 10, 223-230.

13. Koenderink, J.J., Bouman, M.A., Bueno de Mesquita, A.E. and Slappendel, S. (1978). Perimetry of contrast detection thresholds of moving spatial sine-wave patterns, I, II, III & IV. *J. Opt. Soc. Am.*, 68, 845-865.

14. Spencer, T.J. (1969). Some effects of different masking stimuli on iconic storage. *J. Exp. Psychol.*, 81, 132-40.

15. Schiller, P. and Smith, M. (1968). Monoptic and dichoptic metacontrast. *Perc. and Psychophysics*, 3, 739-747.

T A B L E 1

SIZE AND LUMINANCE DIFFERENCE CONDITIONS

Discrimination of disc size			Discrimination of disc luminance			Discrimination of bar length		
Diameter of test disc (')	Diameter difference (')	Contrast*	Luminance of test disc (cd/m²)	Luminance difference (cd/m²)	Contrast*	Length of test bar (')	Length difference (')	Contrast+
72	0	0	23		0	72		0
76.3	4.3	0.06	25.8	2.8	0.12	76.2	4.2	0.06
79.2	7.2	0.10	33.6	10.6	0.46	78.9	6.9	0.10
85.7	13.7	0.19	39.6	16.6	0.72	84.7	12.7	0.18
91.4	19.4	0.27	46.7	23.7	1.03	91.1	19.1	0.27
96.5	24.5	0.34	49.0	26.0	1.13	96.4	24.4	0.34
101.5	29.5	0.41	50.8	27.8	1.21	101.6	29.6	0.41
116.6	44.6	0.62	59.1	36.1	1.57	116.5	44.5	0.62
119.5	47.5	0.66				121.8	49.8	0.69
133.2	61.2	0.85						
152.6	80.6	1.12						

* Contrast is defined as $C_L = \dfrac{L_T - L_S}{L_S}$ and $C_S = \dfrac{D_T - D_S}{D_S}$ where L_T and D_T are the luminance and diameter of the test disc respectively and L_S and D_S the luminance and diameter of the standard comparison disc.

+ Contrast is defined as $C_s = \dfrac{l_t - l_s}{l_s}$ where l_t is the length of the test bar and l_s is the length of the standard comparison bar.

T A B L E   2

FALSE-ALARM RATES[†]

Eccentricity (°)	Horizontal configuration	Vertical configuration
3	15%	33%
6	18%	39%
10	23%	38%
14	28%	32%
18	25%	28%

[†]Expressed as a percentage of occasions on which the observers responded 'different' when the lengths were the same. Data are for nine observers at each eccentricity and for both orientations.

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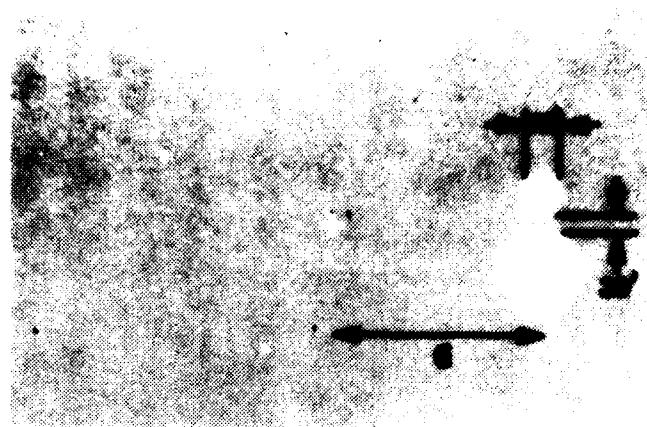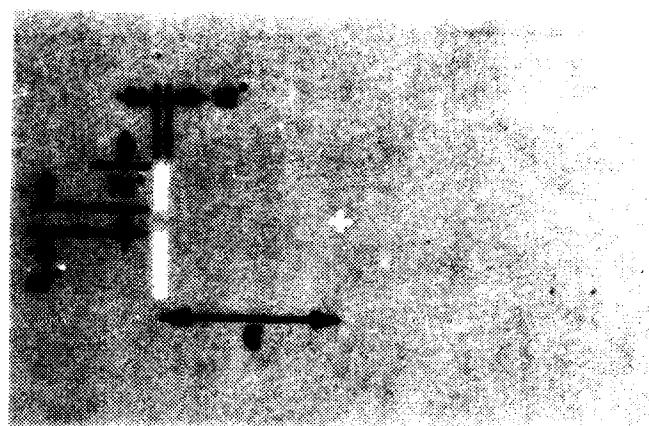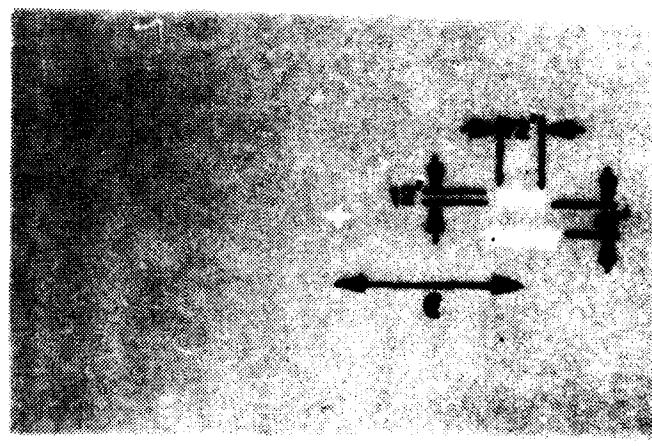
FIG. 1 - Stimulus configurations used in the experiments.
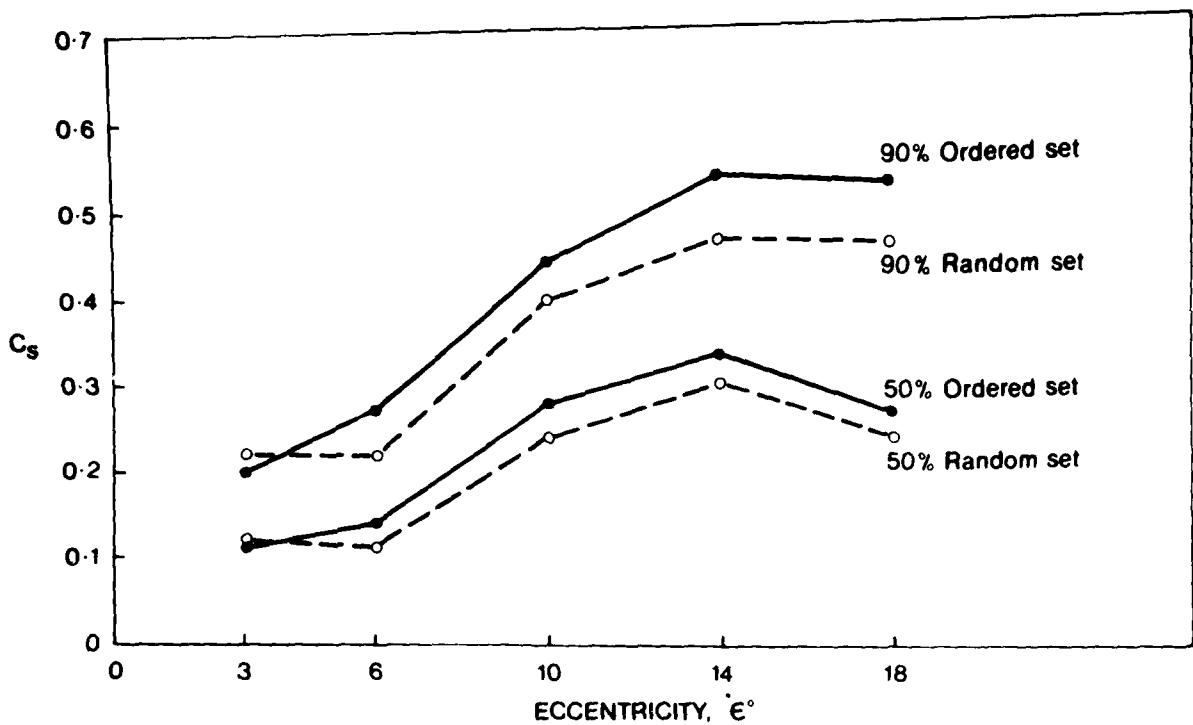
FIG. 2 – Size contrast thresholds, C_S, for the P50 and P90 levels of detectability against eccentricity ϵ. The solid lines are for the ordered set of presentations, the dashed lines for the random presentations (see text).
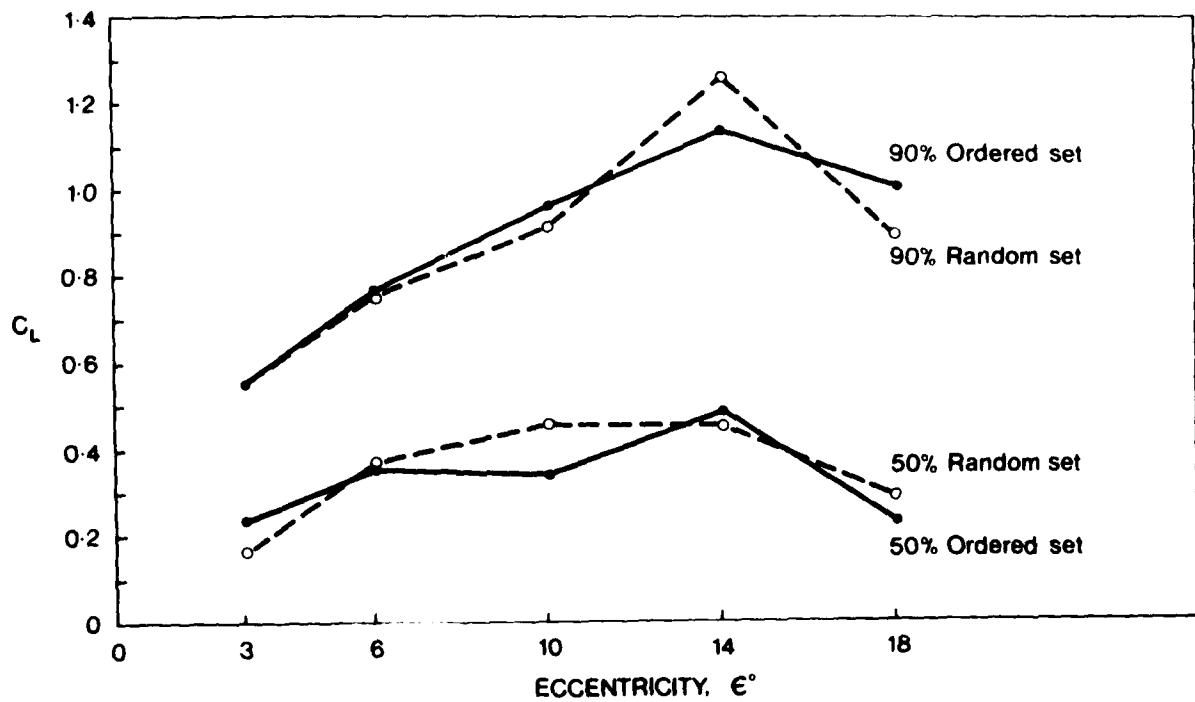
FIG. 3 – As for Fig. 2 but for luminance contrast thresholds, C_L, (note that ordinate scale is doubled).
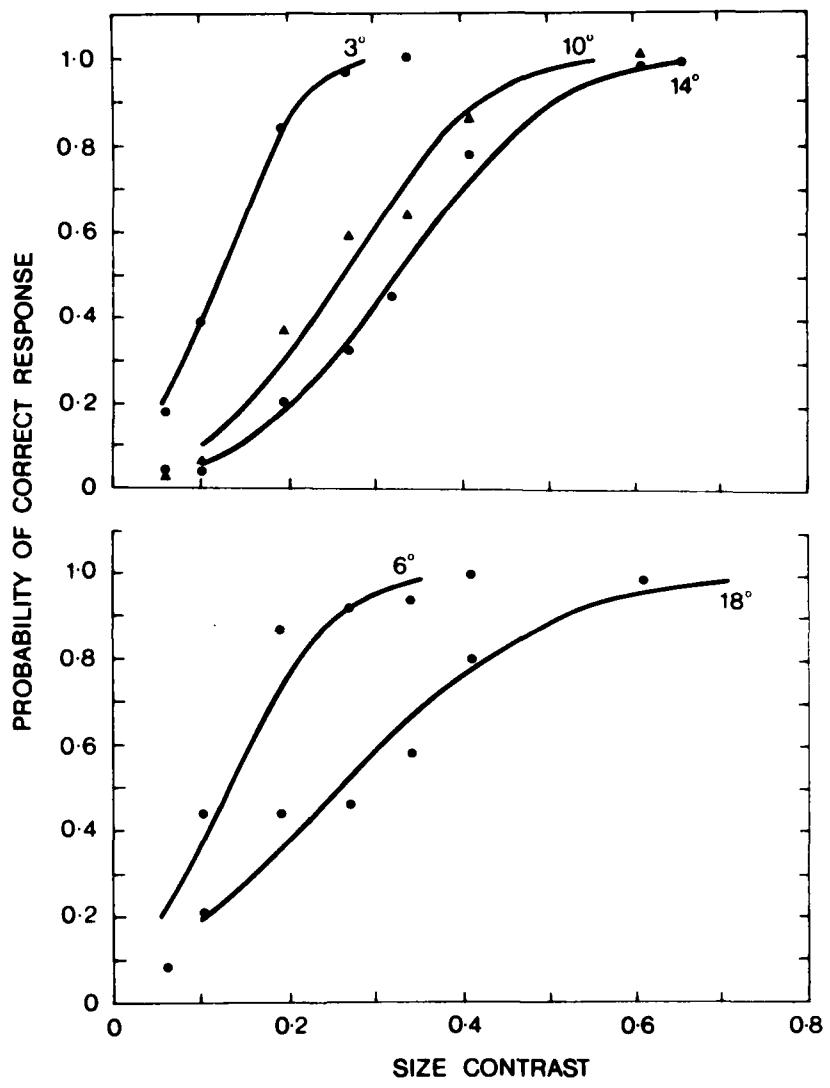
FIG. 4 – Probability of a correct response for the discrimination of size
differences of two discs located at 5 eccentricities from 3° to 18°.
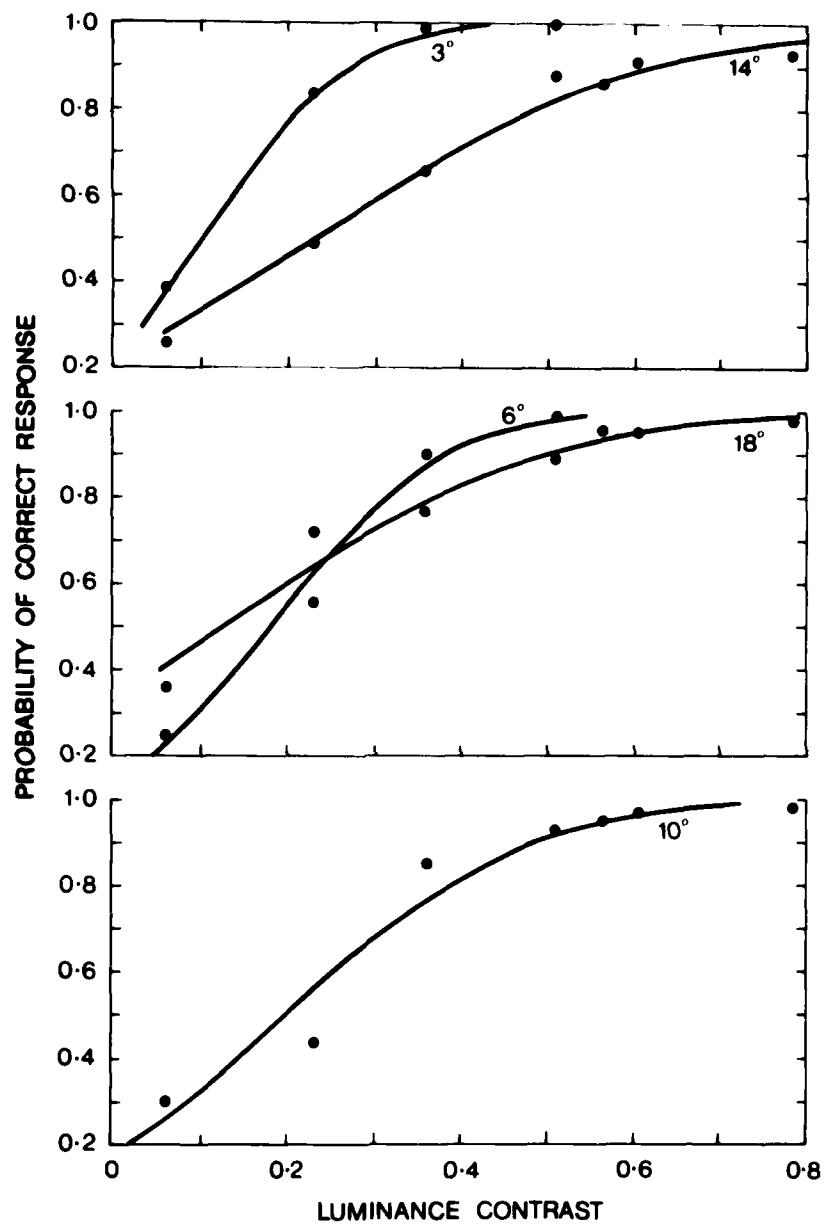
FIG. 5 - Probability of a correct response for the discrimination of
luminance differences of two discs located at 5 eccentricities
from 3° to 18°.
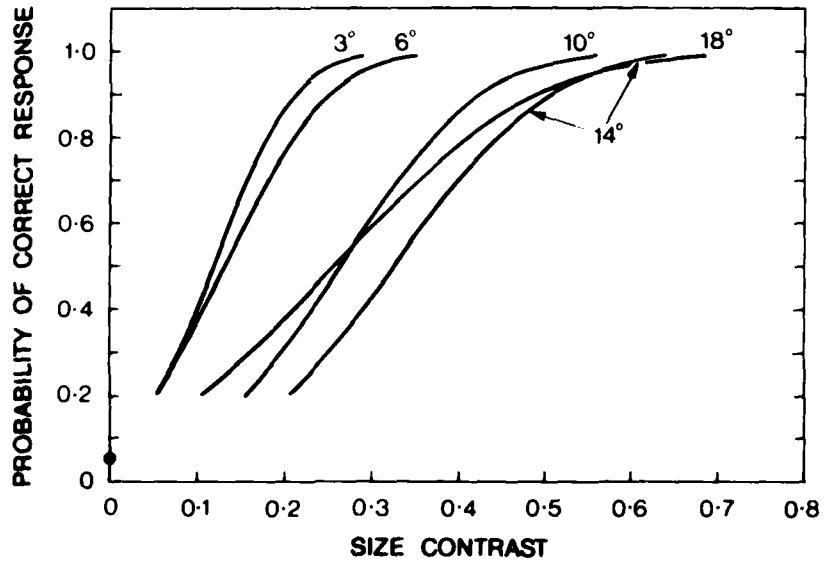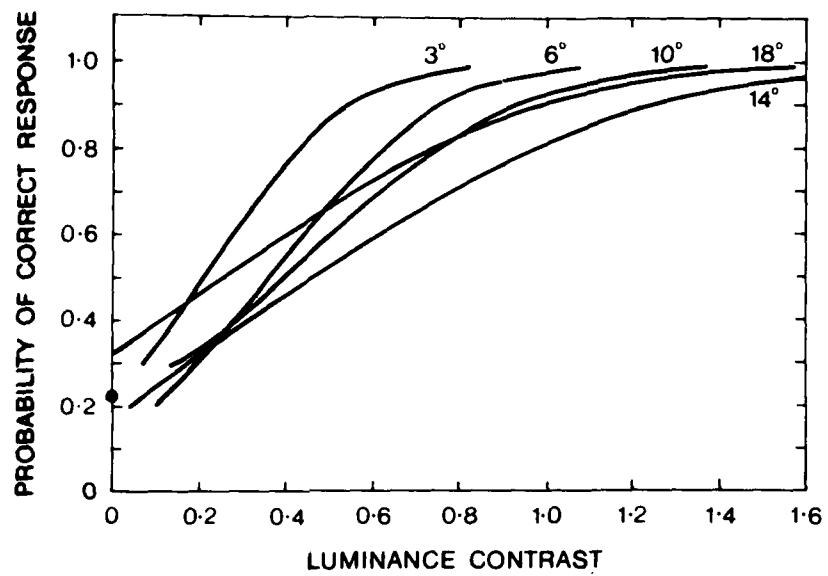
FIG. 6 – Response ogives from Figs. 4 and 5 collected together for ease
of comparison. The data points on the ordinate axes are the
two false alarm rates.
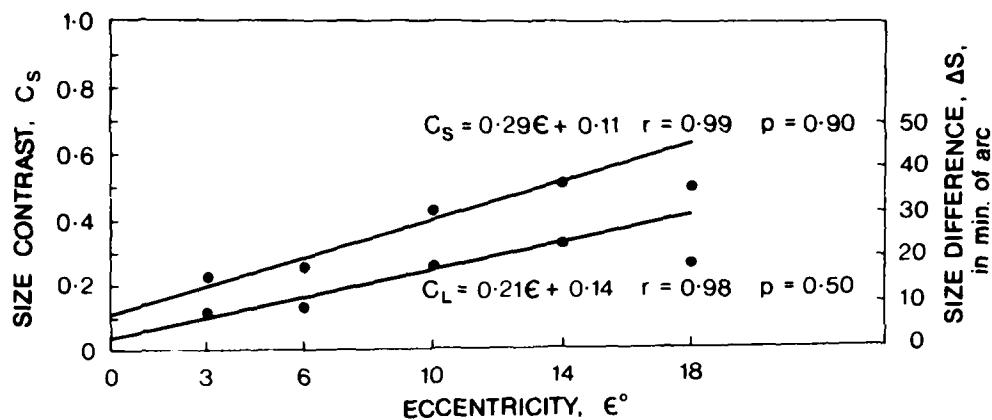
FIG. 7 – Contrast thresholds at two probabilities of correct response
(p = 0.5 and p = 0.9) for the discrimination of size differences
of two discs as a function of eccentricity. The regression
equations are given together with the correlation coefficient,
r, for all data points excluding the 18° points.
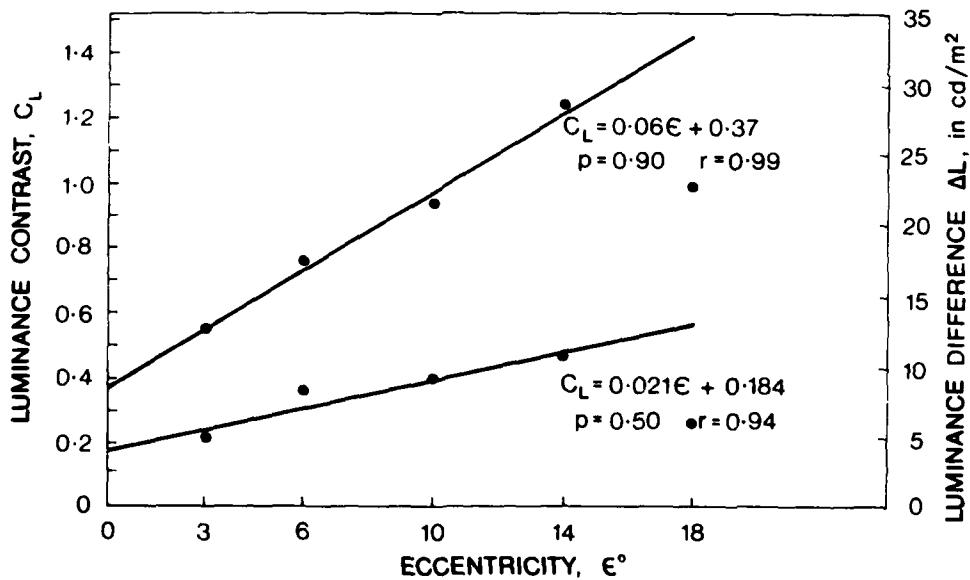
FIG. 8 – As for Fig. 7 but for luminance contrast threshold. The 18° data
points have been excluded from the straight line fit.
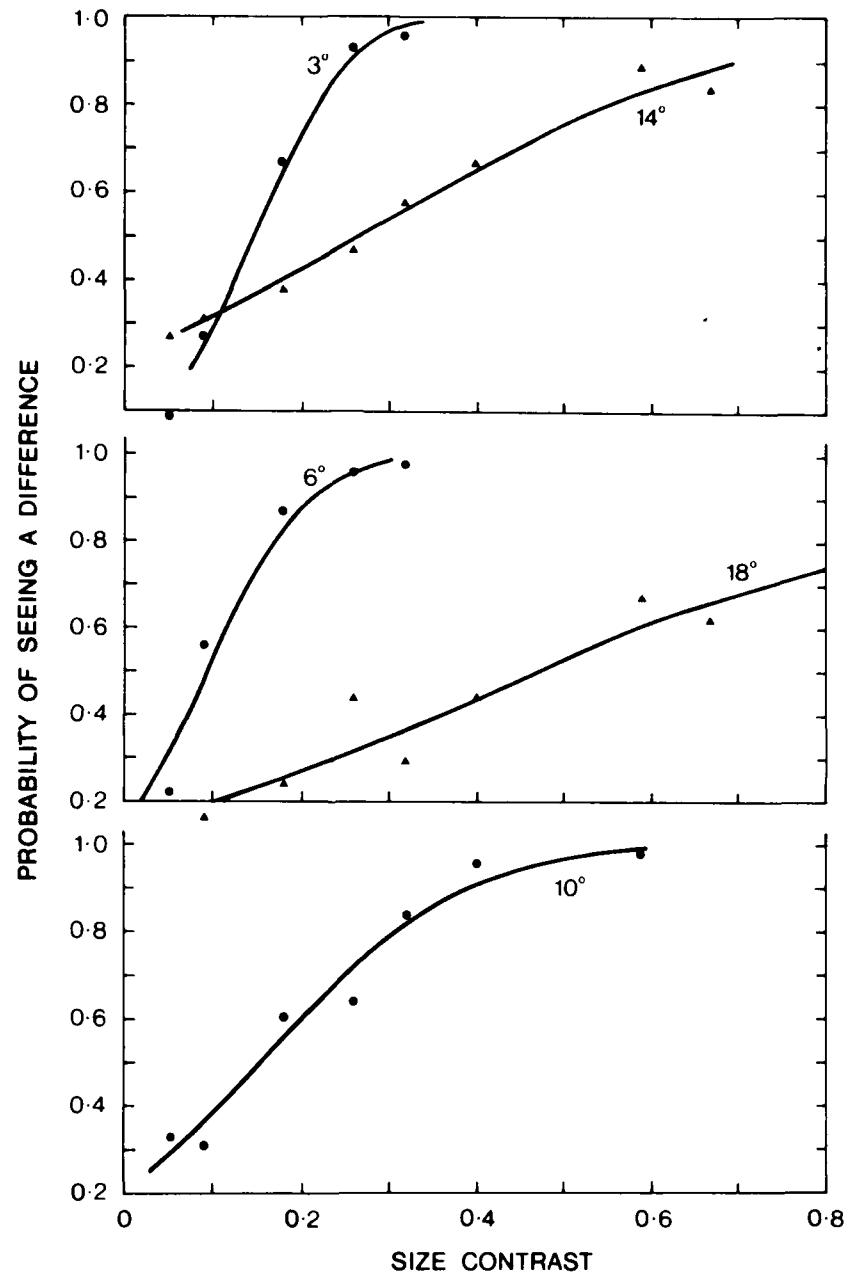
FIG. 9 – Probability of a correct response for the discrimination of the
length of two bars when the bars are horizontally aligned with
the eccentricity as parameter.
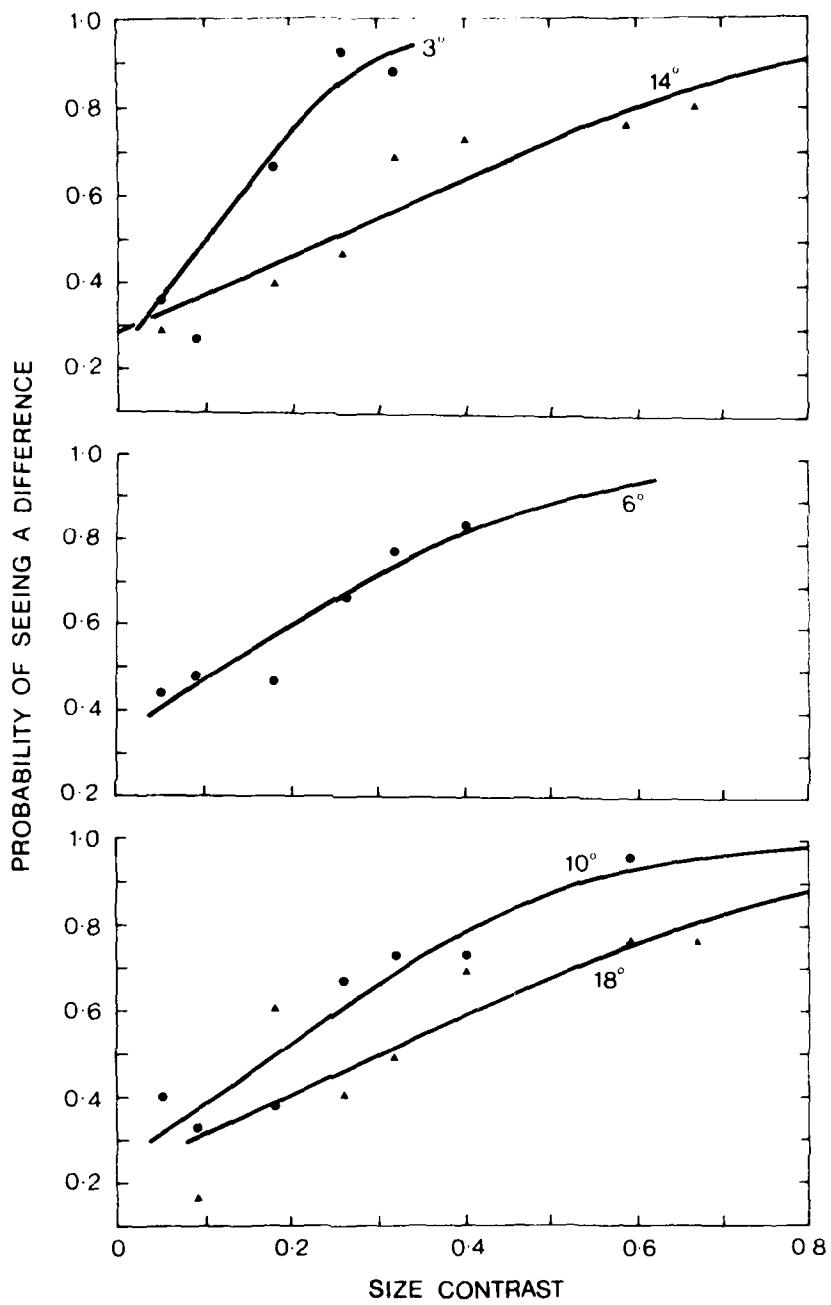
FIG. 10 - Probability of a correct response for the discrimination of the
length of two bars when the bars are vertically aligned with
the parameter.
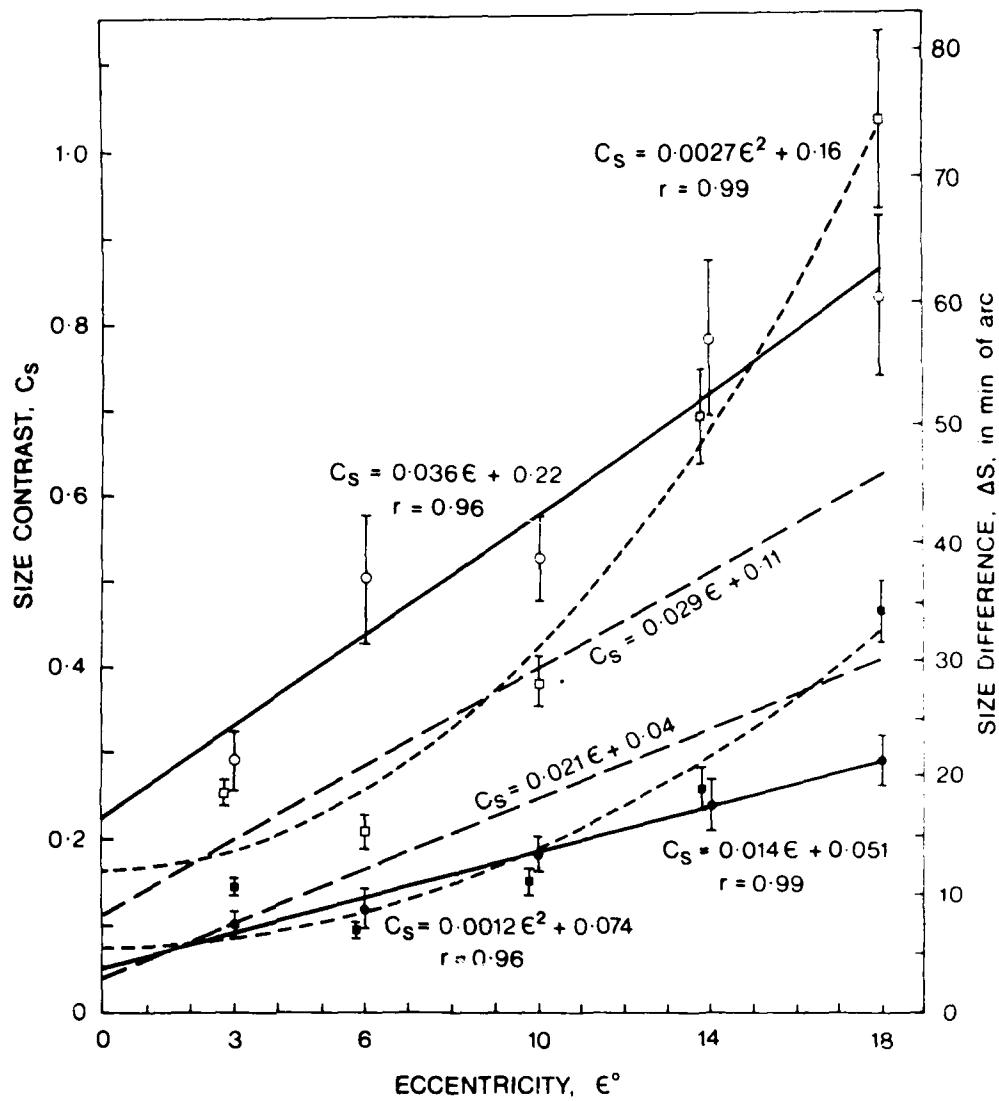
FIG. 11 – Contrast thresholds at two probabilities of correct response
(p = 0.5 and p = 0.9) for the discrimination of bar length as
a function of eccentricity. The filled circles are for the
vertical configuration at p = 0.5; the filled squares are for
the horizontal configuration at p = 0.5; the open circles are
for the vertical configuration at p = 0.9; and the open squares
are for the horizontal configuration at p = 0.9. The solid
lines are the best fit lines to the vertical configuration data,
the small dashed lines are the best fit quadratic lines to the
horizontal configuration data, and the large dashed lines are
the regression lines for the discrimination of disc size
included for the purpose of comparison.
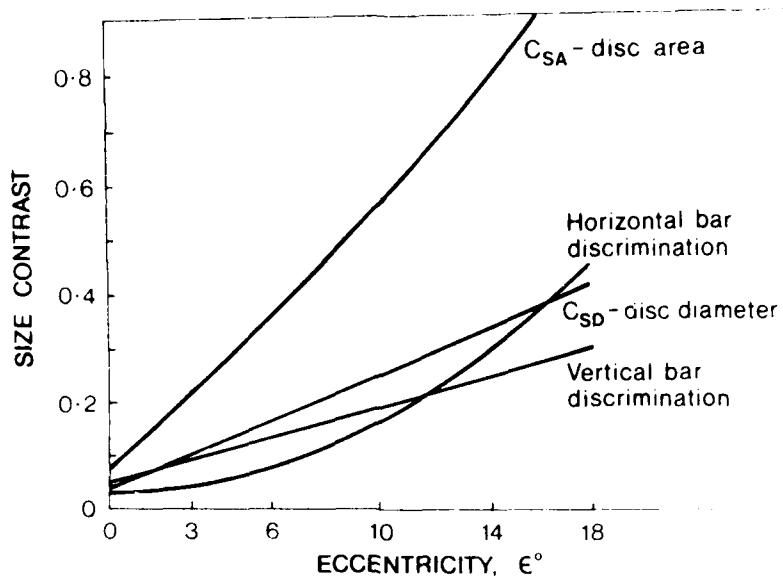
FIG. 12 – The regression lines for discrimination of differences of bar length and disc size as functions of eccentricity compared to the function expected if disc size discrimination were based on differences in area.
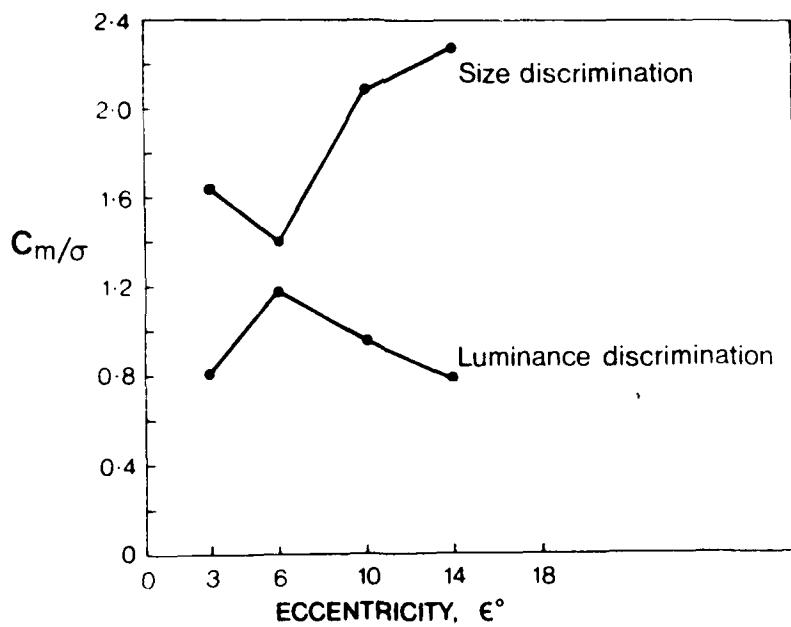

FIG. 13 – The ratio of contrast threshold, C_M, (p = 0.5) and the standard deviation, σ, of the observer response curve versus eccentricity for disc size and luminance discrimination.

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